CONTRIBUTIONS TO THE BIOLOGY OF THE WOUNDFIN, *PLAGOPTERUS ARGENTISSIMUS* (PISCES: CYPRINIDAE), AN ENDANGERED SPECIES

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ABSTRACT.— The woundfin is a small, streamlined, omnivorous cyprinid that is now limited to the Virgin River basin where it was collected in the mainstream and one tributary during the present study. The woundfin occurred most frequently in runs and over sand substrates and less frequently in riffles and over rock substrates. It was common over at least half of its original range within the Virgin River. It was uncommon in the lower mainstream due to habitat alterations and, presumably, predation by and competition with exotic species.

The woundfin belongs to a unique tribe of cyprinids, the Plagopterini, that is characterized by spinous modifications of the anterior dorsal and pelvic rays (Miller and Hubbs 1960). It is a small (<75 mm SL), scaleless, torpedo-shaped fish with large fins, a pair of barbels on the lips, and reduced eyes. Deacon and Minckley (unpubl. mans.) estimate the maximum age to be four years, but most individuals probably do not exceed two years.

At one time the woundfin probably inhabited the larger streams of the lower Colorado River basin (Minckley 1973). It was last collected in the Gila River basin (Arizona) in the 1890s (Miller and Hubbs 1960). It is now limited to the mainstream of the Virgin River and one of its tributaries. The purpose of the present study was to determine the distribution, general ecology, and status of woundfin populations in the Virgin River basin.

Study Area

The Virgin River heads in the Colorado Plateau geologic province in southwestern Utah. It flows southwesterly into the Basin and Range geologic province and empties into Lake Mead 320 km from its source. Prior to the construction of Hoover Dam (1935), the Virgin River discharged directly into the Colorado River. The climate of the Virgin River basin is arid to semiarid, with mild winters, hot summers, and high evaporation rates. The river is characterized by widely variable discharges and high sediment loads.

Methods

Fish were collected with tied nylon minnow seines (3.0, 3.7, 4.6, and 6.1 m long by 1.2 and 1.8 m deep with 3 and 6 mm mesh) between 21 June 1973 and 15 March 1975. Each station (Fig. 1) was sampled with three consecutive seine hauls within each habitat type (run, riffle, or pool). Fish were maintained in 19 liter buckets until sampling was completed and returned alive to the streams. A few specimens were returned to the laboratory preserved in 10 percent formalin.

At each station the following data were collected: water temperature, conductivity, current velocity, stream width, depth of capture, average depth of the habitat, and length of the seine haul.

Fish returned to the laboratory were left in formalin five days, washed in water two days, and stored in 65 percent ethanol. A sterioscopic dissecting microscope was used to examine gut contents. Specimens are housed in the Department of Biological Sciences, University of Nevada, Las Vegas.

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RESULTS

The woundfin was collected in the mainstream Virgin River from Riverside, Nevada, upstream to LaVerkin Springs (=Virgin Springs), Utah, and in the lower reaches of LaVerkin Creek (Fig. 1). It was the most abundant of the native species; 5,000 out of 10,822 native fish collected were woundfin. Woundfin occurred in 33 percent of the collections in the lower mainstream (downstream from Mesquite, Nevada) and made up from 30 to 100 percent of the catch but averaged less than 50 percent. In the middle reaches of the mainstream (downstream from Hurricane, Utah) the woundfin was present in 90 percent of the collections and generally comprised 50 percent of the catch. In the upper mainstream it occurred in 65 percent of the collections and averaged less than 33 percent of the catch. The woundfin was present in all collections in the lower reaches of LaVerkin Creek and generally comprised less than 50 percent of the fish fauna.

The woundfin occurred most frequently in runs (75 percent of all collections), less frequently in riffles (20 percent), and occasionally in pools (5 percent). It was collected over sand (60 percent of all collections), rubble and cobble (30 percent), and mud (10 percent) substrates. The mean depth of capture was 43 cm (SE=13.3, n=38); the average depth of the water was 25 cm (SE=6.2, n=38). In one-half of the collections, woundfin were associated with some type of cover, usually overhanging deadfalls, brush, or trees. Water temperatures ranged from 10.0 to 35.5 C with a mean of 23.7 C (SE=2.3, n=38). Conductivities ranged from 150 to 2650 μmhos (at 25 C) with a mean of about 1100 μmhos. Current velocities ranged from zero to 1.13 m/sec with a mean of 0.42 m/sec (SE=0.09, n=38). In more than 60 percent of the collections woundfin occurred in habitats that were

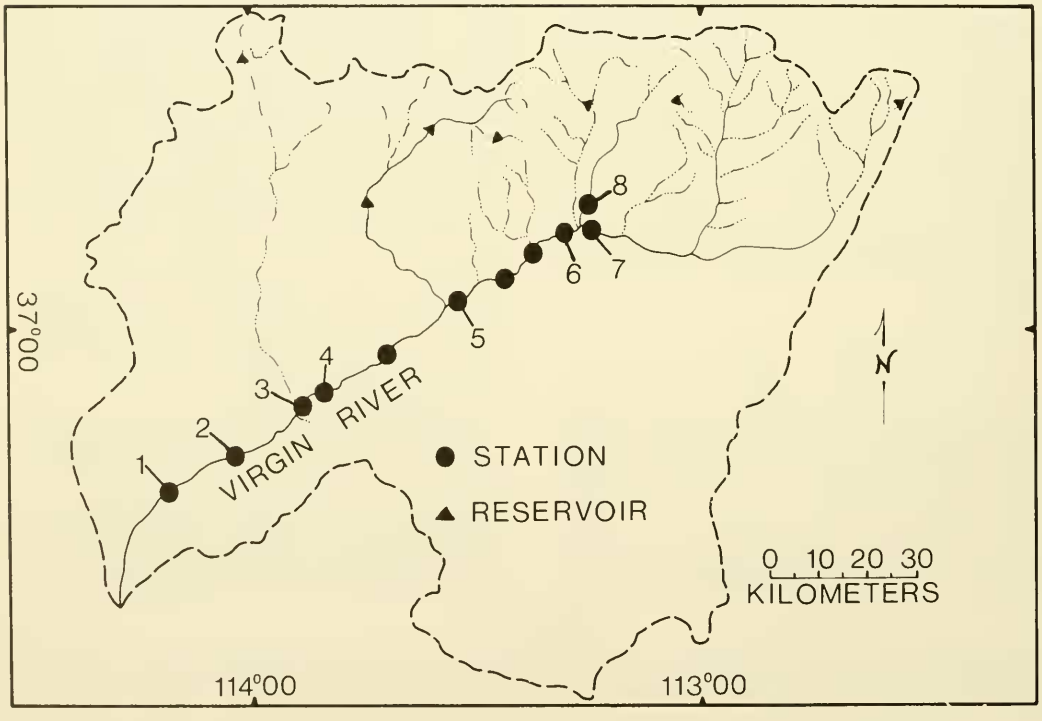

Fig. 1. Map of the Virgin River showing collection localities: (1) Riverside, Nevada; (2) Mesquite, Nevada; (3) Littlefield, Arizona; (4) Arizona Narrows, Arizona; (5) St. George, Utah; (6) Hurricane, Utah; (7) LaVerkin Springs, Utah; (8) LaVerkin Creek, Utah.

considered to be physically unmodified; in the remaining collections it occurred in habitats considered to be moderately to largely modified (irrigation withdrawals and return flows, organic wastes, stream channelization). Native fishes (Table 1) comprised an average of 89 percent (SE = 7.1, n = 38) of collections containing the woundfin.

The spawning habitat and reproductive behavior of the woundfin are not known. Ripe, tuberculated individuals were collected in May. Spawning appeared to commence about April to May and continued through August (Lockhart, unpubl. mans.). Young-of-the-year were collected from early June to mid-August. Juvenile woundfin occupied shallow areas lateral to the main current. When water levels were low, juvenile woundfin often occurred in the main channel.

Woundfin possess a poorly defined stomach occupying about one-fifth of the total gut length. Examination of 14 specimens collected in August partly at Littlefield and partly at the mouth of LaVerkin Creek produced the following items (in order of abundance): sand grains, aquatic insect larvae (predominantly dipterans), filamentous green algae, plant debris, terrestrial insects (mainly ants) and amphipod larvae.

In laboratory aquaria (39 and 208 liters), woundfin initially exhibited no evidence for visual selection of food. Soon after dried foods were introduced into the aquaria, woundfin began milling excitedly over the bottom. Within one month most individuals had begun rising to the surface to feed.

DISCUSSION

DISTRIBUTION.— Within the Virgin River system the woundfin is limited in its upstream distribution by the highly saline LaVerkin Springs (conductivity approximately 15,000 μmhos at 25 C), which enter the river along the Hurricane Fault east of LaVerkin, Utah (Fig. 1). Absence of the woundfin from the river upstream from the springs may be due to the order of appearance of the woundfin in the Virgin River and crustal movement along the Hurricane Fault. Uplift of the Unikaret Plateau (part of the North Rim of the Grand Canyon bounded on the west by the Hurricane Fault) during the Pliocene to Pleistocene could have led to the emergence of LaVerkin Springs (Cook 1960, McKee et al. 1967). Subsequently, the Virgin River may have been invaded by the woundfin, a lower Colorado River basin endemic; its upstream penetration was limited by LaVerkin Springs. The Virgin River roundtail chub is also limited in its upstream distribution by LaVerkin Springs (Cross 1978).

Occurrence of the woundfin in only one

TABLE 1. Phylogenetic listing of the fish fauna of the Virgin River and their general distribution. M = mainstream, T = tributary, H = headwater, N = native species.

Family	Common name	Scientific name	Distribution
Salmonidae	Cutthroat trout	*Salmo clarki*	H
	Rainbow trout	*Salmo gairdneri*	H
	Brook trout	*Salvelinus fontinalis*	H
Cyprinidae	Carp	*Cyprinus carpio*	M
	[n]Speckled dace	*Rhinichthys osculus*	MT
	[n]Virgin River roundtail chub	*Gila robusta seminuda*	M
	Redside shiner	*Richardsonius balteatus hydrophlox*	T
	Red shiner	*Notropis lutrensis*	M
	[n]Virgin River spinedace	*Lepidomeda mollispinis mollispinis*	MT
	[n]Woundfin	*Plagopterus argentissimus*	MT
Catostomidae	[n]Flannelmouth sucker	*Catostomus latipinnis*	MT
	[n]Desert sucker	*Catostomus clarki*	MT
Ictaluridae	Black bullhead	*Ictalurus melas*	M
Poeciliidae	Mosquitofish	*Gambusia affinis*	M
Centrarchidae	Largemouth black bass	*Micropterus salmoides*	M
	Green sunfish	*Lepomis cyanellus*	M
	Bluegill sunfish	*Lepomis macrochirus*	M

tributary is probably related to a combination of physical and chemical factors unique among mainstream tributaries to LaVerkin Creek. The creek originates as saline springs (conductivity approximately 1,200 μmhos at 25 C), has a sand substrate, and is highly turbid. LaVerkin Creek is thus physically and chemically more similar to the mainstream than to the other tributaries. Ash Creek, which enters the Virgin River within 30 m of LaVerkin Creek, is fed by upstream runoff (conductivity about 200 μmhos at 25 C) and is generally cooler and less turbid than LaVerkin Creek. No woundfin were collected in Ash Creek during the study.

REPRODUCTION.— The stimuli that initiate the reproductive cycle of the woundfin are not known. Spawning may be initiated by low, clear water; juvenile woundfin first appear coincident with the period of lowest river discharge. Avoidance of high spring discharges and turbidities would be advantageous because eggs spawned at that time would likely be carried away by the current or buried in silt (there is almost no submergent or emergent vegetation in the mainstream to which eggs could be affixed).

During the summer the Virgin River was often dry through the Arizona Narrows (Fig. 1). Springs emerging above Littlefield accounted for the entire river flow downstream. Two distinct sizes of young-of-the-year woundfin were present in the shallow springs during late summer: a mode about 10 mm and another about 25 mm. Apparently adult woundfin had moved into the spring area to spawn, probably in response to the low, clear water.

Lockhart (unpubl. ms.) noted that young-of-the-year woundfin exhibited growth through October. October to December appeared to be the period of highest mortality for all woundfin, coinciding with minimum water temperatures and reduced food availability.

FOOD HABITS.— From the small sample of fish examined, woundfin appear to be omnivorous. The temporal variability of the Virgin River would place a premium on generalized or opportunistic feeding habits. The relative shortness of the gut (intestine length/standard length [Odum 1970] is slightly less than unity) would seem to preclude a predominantly algal-detrital diet. It may be that bacteria, protozoans, and microalgae adsorbed to algae and detrital particles supply the nutrients or aid in the breakdown of plant material as in the mullet, *Mugil cephalus* (Odum 1968, 1970).

CHANGES IN ABUNDANCE.— Collections and fieldnotes examined at Brigham Young University, the University of Michigan, the University of Nevada, Las Vegas, and the U.S. National Museum indicate that woundfin abundance in the mainstream Virgin River upstream from Mesquite Nevada, has not appreciably changed since at least the 1930s (few earlier records exist). Woundfin populations downstream from Mesquite have, however, declined. The extirpation of the woundfin from the Salt and Gila rivers in Arizona was attributed to drought, agricultural operations, water storage and diversion, and the introduction of exotic species (Miller and Hubbs 1960, Minckley and Deacon 1968). These factors operate, to a greater or lesser extent, within the Virgin River basin.

Seasonal drying of extensive reaches of the mainstream has reduced the habitable range of the woundfin. Drying of the river during low discharge periods undoubtedly occurred naturally, although probably infrequently, before irrigation became widely used. At present the agricultural demand for water regularly results in dry reaches of river downstream from Hurricane, Utah, through the Arizona Narrows and downstream from Mesquite, Nevada, to Lake Mead during the summer. Reduction of available habitat was thought to be the primary factor accounting for the decline of Virgin River roundtail chub populations (Cross 1978).

Introduced species have also contributed to the decline of woundfin populations in the lower river via predation and, presumably, competition. Predation on the native species by exotics was facilitated by the creation of Lake Mead and subsequent introductions of fish into the lake. Potential predators on the woundfin, including largemouth black bass, bluegill and green sunfish, black bullheads, and mosquitofish, are present in the lower river mainly as sea-

sonal (summer and fall) emigrants from Lake Mead.[2] Examination of the stomachs of two largemouth black bass (118 and 167 mm SL) from August collections revealed one unidentifiable fish in the first and a 50 mm woundfin in the second.

Competition is more difficult to prove and only circumstantial evidence exists for competition between the red shiner, a small, omnivorous cyprinid, and the woundfin. Downstream from Mesquite, woundfin abundance decreased while red shiner abundance increased. At Station 1 (Fig. 1) the red shiner regularly comprised 90 percent or more of the fauna; at Station 2 it averaged about 40 percent of the fauna; and at Station 3 it was captured infrequently. This situation could have resulted from a deterioration of the habitat beyond the tolerance range of the woundfin, but not beyond that of the red shiner. The red shiner is capable of withstanding intermittence, high temperatures, and high turbidities (Koster 1957, Cross 1967). Within its native range (midwestern United States) the red shiner rarely becomes abundant in clear streams with constant discharge and large populations of other cyprinids, but it increases rapidly in abundance when drought decreases streamflow and alters the composition of the fauna (Cross 1967).

Alternatively, the decline of the woundfin may have been a result of competition with the red shiner. The woundfin is also particularly well adapted to the extreme fluctuations in discharge, suspended sediment, and temperature. It commonly occurred in habitat unsuitable for the other native species due to high temperatures (the LD_{50} for woundfin acclimated at 21.5 C was 34.5 C (Lockhart, unpubl. mans.), minimal river flow, or organic pollution. The scarcity of woundfin in the lower river is not likely attributable to the poor quality of the habitat—comparable conditions occur upstream from the Arizona Narrows where woundfin are frequently the only species collected. What is more probable is that as a result of the presence of the red shiner, woundfin abundance has declined. A similar correlation between an increase in abundance of the red shiner and the disappearance of the native cyprinids *Meda fulgida* and *Tiaroga cobitis* was observed in the Gila River basin in Arizona (Minckley and Deacon 1968, Minckley 1973).

The woundfin presently persists over at least half of its original range within the Virgin River basin. The precarious nature of its existence has prompted its inclusion in the U.S. Bureau of Sport Fisheries and Wildlife (1973) listing of endangered species. The continued existence of the woundfin in the Virgin River basin is directly linked to the amount of further physical, chemical, and biological alterations of the mainstream habitat.

ACKNOWLEDGMENTS

The following participated in various aspects of the fieldwork, and their assistance is gratefully acknowledged: H. A. Berry, P. J. Calos, C. D. Deacon, J. E. Deacon, G. C. Faber, J. Lockhart, and L. Loetterle. Access to museum collections was made possible by: Dr. R. R. Miller (University of Michigan Museum of Zoology); Dr. W. W. Tanner (Brigham Young University); Dr. E. A. Lachner (U.S. National Museum); and Dr. W. L. Minckley (Arizona State University). The figure was prepared by Jan Shines. A special acknowledgment goes to J. E. Deacon, my major professor, for his ideas and encouragement during the study.

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[2]Few introduced fish persist in the river through the spring highwater period. Consequently, annual flooding has limited the upstream penetration of introduced species; the farthest upstream penetration recorded during the study was 100 km. The majority of the introduced fishes were collected within 70 km of Lake Mead.

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